(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
29 November 2001 (29.11.2001)

PCT

(10) International Publication Number
WO 01/90533 A1

(51) International Patent Classification⁷: E21B 41/00

(21) International Application Number: PCT/GB01/02283

(22) International Filing Date: 22 May 2001 (22.05.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

0012386.9	22 May 2000 (22.05.2000)	GB
0012545.0	23 May 2000 (23.05.2000)	GB
0012932.0	26 May 2000 (26.05.2000)	GB
0013499.9	2 June 2000 (02.06.2000)	GB

(71) Applicant *(for all designated States except US)*: SMITH INTERNATIONAL, INC. [US/US]; 16740 Hardy Street, Houston, TX 77205-0068 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: MCGARIAN, Bruce [GB/GB]; 23 East Glebe, Stonehaven, Aberdeen AB3 2HW (GB). CHADWICK, Robert, Ian [GB/GB]; Smith Red Baron, Badentoy Avenue, Badentoy Park, Portlethen AB12 4YB (GB). TAYLOR, Gary, Alexander [GB/GB]; Craigieview, Auchnagatt, Ellon, Aberdeenshire AB41 8UG (GB).

(74) Agents: GOODENOUGH, Nigel et al.; A.A. Thornton & Co., 235 High Holborn, London WC1V 7LE (GB).

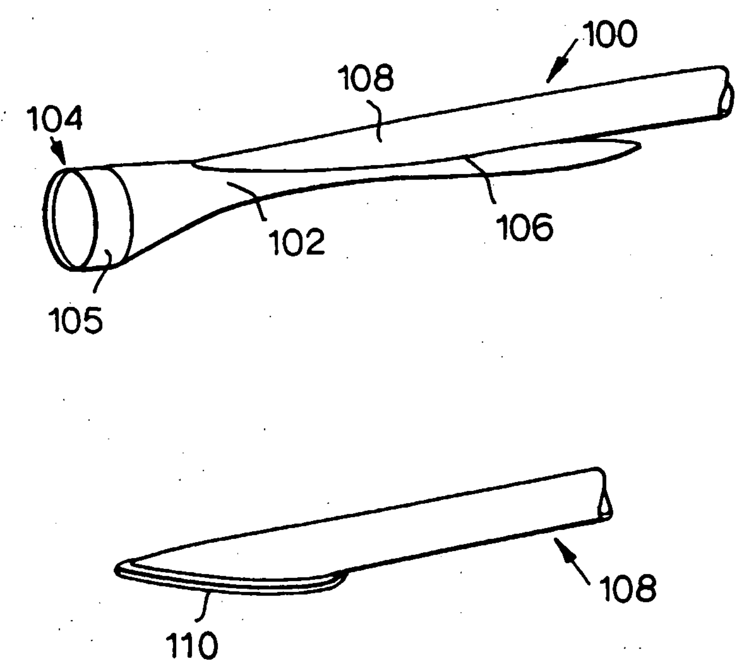
(81) Designated States *(national)*: CA, NO, US.

(84) Designated States *(regional)*: European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: SEALED LATERAL WELLBORE JUNCTION



(57) Abstract: The present invention relates to downhole drilling operations, and more particularly, to the completion of lateral boreholes. Apparatus (100) is provided comprising a tubular liner portion (108) for lining a portion of a lateral borehole adjacent an opening of a borehole into the lateral borehole. An end portion of said tubular liner portion (108) is provided with a flange element (102) having a curved surface for locating in abutment with an area of main borehole surrounding said opening. A method of using said apparatus (100) is also provided.

WO 01/90533 A1

SEALED LATERAL WELLBORE JUNCTION

The present invention relates to downhole drilling operations and, more particularly, to the completion of lateral boreholes.

One object of any lateral borehole completion operation is to provide a means of preventing shale transfer between the main borehole (leg 1) and the lateral borehole (leg 2). It is particularly desirable to prevent the ingress of shale from the lateral leg, through the window, and into the main leg. A consequence of such an ingress can be a plugging of production.

The problem of providing an adequate sealing of lateral boreholes during a lateral completion operation is discussed in the Society of Petroleum Engineers (SPE) paper 57540. The paper provides a solution to the problem, namely the MX sleeve or multi-lateral Tie Back Insert (MLTBI as it was originally known). Whilst this proposed system may be operated effectively, it does not allow full re-entry to both the main borehole (leg 1) and the lateral borehole (leg 2). Although the lateral borehole is mechanically accessible, the main borehole is merely hydraulically accessible. Modification to the proposed system may allow mechanical access to the main borehole as well as the lateral borehole, but this access would be very limited. It is of course desirable to provide full bore access to both legs so as to allow unrestricted use of conventional downhole equipment.

A further solution is the "hook" hanger (or liner) system discussed in US 5,477,925. With reference to Figure 1 of the accompanying drawings, it will be understood that the aforementioned hook hanger system comprises a hook liner 2 of a generally cylindrical shape. The liner 2 is provided with a preformed opening 4. The geometry of the opening 4 is such that, when a lower end 6 of the liner 2 has passed through a casing window and into an associated lateral borehole, said opening 4 can be aligned in such a way as to provide full mechanical access to the portion of main borehole located downhole of the main/lateral junction. More specifically, the liner 2 can be arranged so as to project from the lateral borehole with the opening 4 spanning the main borehole and facing downhole.

In addition to the opening 4, two ribs 8 are located diametrically opposite one another on the external cylindrical surface of the liner 2. Each rib 8

extends helically along the length of the liner 2 and, in use, undertakes a "hooking" role wherein the portion of casing adjacent the window is engaged by each rib 8 so as to ensure that the opening 4 is located correctly.

The prior art hook hanger system is employed once a window mill 10 and whipstock 12 have been used, in a conventional manner, to cut a window 14 in the casing 16 of a main borehole (as shown in Figures 2 and 3). A lateral borehole is then drilled from the window 14 into surrounding formation. The aforementioned system is then used to line and thereby seal the lateral borehole. This is achieved by attaching a tubing string (by means of a crossover element) to the lower end 6 of the liner 2 and running the tubing string (followed by the liner 2) into the lateral borehole. Conveying of the tubing string (not shown) through the lateral borehole is preferably assisted by means of a bent joint. Once the tubing string has been fully deployed in the lateral borehole, the lower end 6 of the liner 2 is passed through the window 14. The ribs 8 then locate against the window profile.

Entry into the lined lateral is achieved using a string comprising a further bent joint and suitable guide means. The guide means may be a mule shoe giving an orientation of the leg on the bullnose relative to the bent joint entry to either leg 1 (i.e. the main borehole) or leg 2 (i.e. the lateral borehole).

With regard to entry into the portion of main borehole located below the main/lateral junction, it will be noted that the widest section 18 of the casing window 14 extends for only a relatively short distance downhole. It is through this widest section 18 that the tubing string and lower end 6 of the liner 2 is run. However, it will be appreciated that, in order to ensure adequate clearance for insertion through the window 6, the liner 2 must be somewhat narrower than said window section 18. As a result, an undesirably restrictive lateral borehole can result.

Embodiments of the present invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a schematic perspective view of a prior art hook hanger system;

Figure 2 is a schematic cross-sectional view of conventional mill and whipstock cutting a casing window;

Figure 3 is a schematic perspective view of the casing window of Figure 2;

Figure 4 is a schematic perspective view of a first embodiment of the present invention;

Figure 5 is a schematic perspective view of a lateral liner portion of the first embodiment;

Figure 6 is a schematic perspective view of a second embodiment of the present invention;

Figure 7 is a partial cross-sectional view of the first embodiment located in a final position adjacent a casing window;

Figure 8 is a partial cross-sectional view of a third embodiment of the present invention located in a final position adjacent a casing window;

Figure 9 is a schematic perspective view of a fourth embodiment of the present invention;

Figure 10 is a schematic perspective view of a fifth embodiment of the present invention;

Figure 11 is a schematic partial internal view of the fifth embodiment;

Figure 12 is a schematic perspective view of the fifth embodiment within a main borehole casing;

Figure 13 is a schematic perspective view of the fifth embodiment located adjacent a main borehole window;

Figure 14 is a schematic part cross-sectional view of a mill and whipstock system for cutting a preferred window profile;

Figure 15 is a schematic perspective view of the preferred window of Figure 14;

Figure 16 is a table of procedural steps for completing a lateral borehole;

Figures 17 to 19 schematically show a flange liner being run into a lateral borehole which has not been provided with an undercut;

Figures 20 and 21 schematically show a flange liner being run into a lateral borehole which has been provided with an undercut;

Figure 22 schematically shows window and deployed flange liner positions relative to a widetrack whipstock;

Figure 23 schematically shows window and deployed flange liner positions relative to a gauge max whipstock;

Figures 24 and 25 schematically show a sixth embodiment of the present invention comprising a collapsed lateral liner portion; and

Figures 26 and 27 schematically show use of the fourth flange liner in an eccentric wellbore casing.

A first embodiment 100 of the present invention is shown schematically in the perspective view of Figure 4. The first embodiment 100 may be termed a "flange" liner since it comprises a flange part constructed from a tubular element 102. The tubular element 102 is profiled so as to enable its diameter to be accommodated within a slightly larger tubular (i.e. a main borehole casing). An uphole end 104 of the tubular element 102 is cylindrical in shape, whereas the portion of tubular element 102 downhole of said uphole end 104 is merely part cylindrical (i.e. open on one side). More specifically, said uphole end 104 is provided with a part spherical node 105 which, in use, assists in centralising the tubular element 102 within a main borehole regardless of the angle of said element 102 to said main borehole. Also, the tubular element 102 is provided with an elliptical aperture 106. The aperture 106 is elongate and extends along the part cylindrical portion of the tubular element 102.

The aperture 106 receives a lateral liner portion 108 (see Figure 5) which is attached to the tubular element 102 by means of welding. The lateral liner portion 108 is provided with a flange 110 at the end secured to the tubular element 102 so as to assist with its correct location relative to said element 102. The lateral liner portion 108 is inserted through the tubular aperture 106 and welded so that the flange 110 abuts the interior surface of the tubular element 102. As an alternative arrangement, the flange 110 may be secured to the exterior surface of the tubular element 102. In a development of the flange liner 100, Figure 6 shows a second embodiment 112 of the present invention wherein a ring seal element 114 has been provided on the external surface of the tubular element 102 about the lateral liner portion 108. The seal element 114 can be bonded to said external surface by means of an appropriate adhesive or retained within a channel or groove defined in or on said

surface. In use, the seal element 114 abuts the main borehole casing and encircles the casing window so as to assist in preventing fluid flow between the lateral borehole and the region located between the main borehole casing and the tubular element 102.

Each flange liner 100,112 is sized in view of the main and lateral boreholes with which it is to be used. The diameters and radii of each liner 100,112 are critical in as much as a close fit of liner components 102,108 relative to the main and lateral boreholes is desirable in order to eliminate shale ingress into the main borehole casing. With this in mind, it should be understood that, in use, each flange liner 100,112 is intended to finally locate with the lateral liner portion 108 projecting into the lateral borehole. Whilst in this position, the part spherical node 105 should abut the full circumference of the internal surface of the main borehole casing and an area of tubular element 102 encircling the lateral liner portion 108 should also abut an area of said internal surface encircling the casing window.

A schematic part cross-sectional view of the first embodiment 100 is shown in Figure 7 located in the above described final position. It will be seen that the downhole edge 116 of the casing window is in abutment with both the external curved surfaces of the tubular element 102 and lateral liner portion 108. As such, said downhole edge 116 may support the weight of the flange liner 100 and prevent further movement thereof down the main and lateral boreholes.

However, each flange liner 100,112 is primarily sized so as to allow it to run smoothly through the main borehole casing prior to achieving the ideal final position indicated above. Accordingly, each flange liner 100,112 must be sized so as to be deployable through the radii of curvature commonly found in well bores (for example, up to 15°/100' for a 7" casing – but not limited to such cases). For a 7" main borehole casing, the lateral liner portion 108 may be provided as a 4½" tubing.

In order to assist with running the aforementioned flange liners 100,112 in hole and to minimise deflection of lateral lining attached to the downhole end of the lateral liner portion 108, one or more flex joints (such as a knuckle joint) are located in said lateral liner. It is particularly desirable to locate a flex joint adjacent said downhole end of the lateral liner portion 108. The use of means for allowing bending of said lateral lining (particularly that lining located adjacent liner portion 108) will

reduce the possibility of lateral lining collapse or, indeed, kinking or crimping of the flange liners 100,112 themselves.

Despite the use of flex joints, the ideal dimensions of a flange liner (from the view point of its final position as discussed above) may be compromised by the need to run through a main borehole having, for example, a particularly restrictive radius of curvature. In these circumstances, the main/lateral junction sealing characteristics associated with the flange liner alone may not be adequate. It may then be necessary to incorporate cementing port collars and external casing packers in the lateral tubing string so that the area surrounding the main/lateral junction can be cemented if so desired. An effective barrier to shale ingress can be thereby created.

Although the two flange liners 100,112 described above are located in position adjacent a casing window by engagement of the downhole window edge 116 (see Figure 7) with both the tubular element 102 and the lateral liner portion 108, a mechanical anchoring device should ideally also be provided adjacent the uphole end 104 of the tubular element 102. Such a device may be set with any appropriate means (for example, string weight or hydraulics) and is particularly desirable since it prevents uphole movement of a flange liner. However, it should be appreciated that such a device may not be necessary in certain circumstances (for example, in a relatively simple main/lateral junction arrangement). Where an anchoring device is used, annular seal assemblies may be provided (possibly as part of said device) adjacent the uphole end of the flange liner.

Also, as shown by the third embodiment 118 in Figure 8, the aforementioned final position adjacent a casing window can be achieved by the engagement of a laterally extending protrusion 120 with a downhole edge of said window. The protrusion 120 extends laterally from a downhole portion of the tubular element 102 spaced downhole from the lateral liner portion 108. The protrusion 120 and tubular element 102 form a hook shape having a generally downwardly facing opening for receiving the downhole window edge as the third flange liner 118 is pressed down the main borehole.

A fourth embodiment 150 of the present invention is shown in Figure 9 of the accompanying drawings. The fourth flange liner 150 is provided as two discrete components 152,154. The first discrete component 152 is largely identical to

the first flange liner 100 shown in Figure 4 and is manufactured in the same manner. The first component 152 may however be based on the design of the second or third flange liners 112,118 (with the same modifications as described hereinafter with relation to the first liner 100). The only difference between said first component 152 and the first flange liner 100 is that said first component 152 has a modified uphole end 156 of the tubular element 158. The modified uphole end 156 is part cylindrical (rather fully cylindrical with a spherical node) and has an upper edge 160 for abutment with the second discrete component 154. A lateral liner portion 162 extends from an elliptical aperture 164 in the tubular element 158.

The second discrete component 154 is an elongate cylindrical sleeve having a preformed window 166 which, in use, is aligned with the window provided in the main borehole casing. The preformed window 166 is substantially the same size and shape as the main borehole window and, when in its final downhole position, locates on the opposite side of the tubular element 158 therefrom. An uphole end 168 of the second component 154 is provided with a downhole facing shoulder 170 for pressing downwardly on the upper edge 160 of the first discrete component 152. The shoulder 170 extends in a circumferential direction about the second component 154 and is axially located so that the aperture 164 of the first component 152 axially aligns with the preformed window 166 when the shoulder 170 and upper edge 160 abut one another. Angular alignment of the aperture 164 and preformed window 166 is ensured by the abutment of two longitudinally extending edges 172 of the first component 152 with two longitudinally extending shoulders 174 on the second component 154 (only one visible in the view of Figure 9). The longitudinal edges 172 of the first component 152 continue downwardly from the upper edge 160 and the longitudinal shoulders 174 continue downwardly from the downhole facing shoulder 170. The two longitudinal shoulders 174 themselves continue downwardly into a mule shoe profile 178 which, in use, can be received in a mating profile within the main borehole casing so as to correctly orientate the flange liner 150 and ensure that the lateral liner portion 162 aligns with the main borehole window.

The uphole end 168 of the second component 154 is provided with anchor and seal means (not shown). The downhole end of the second component 154 is provided with a seal sub 180 having circumferential seal elements 182 and a

bullnose/wireline entry guide 184 at its lowermost end. The second component 154 may also be provided with a whipstock/deflector latch profile located between the seal sub 180 and the preformed window 166 so as to assist with depth and orientation finding.

In use, the fourth flange liner 150 is run downhole with first component 152 axially displaced so that the lateral liner portion 162 is located substantially below the second component 154. This arrangement allows the liner 150 to locate within the internal diameter of the main borehole casing. The liner portion 162 (or attached lateral liner tubing) preferably runs in contact with the main borehole casing so that, as said portion 162 approaches the main borehole window and the liner 150 is appropriately orientated by the aforesaid means, the liner portion 162 (or attached tubing) tends to spring into the main borehole window. Biasing means may alternatively be provided for biasing the liner portion 162 (or attached liner tubing) into the window. The first component 152 then locates in the main borehole window as described in relation to Figure 7. The second component 154 concurrently runs downhole so that the preformed window 166 aligns with the aperture 164 and the main borehole window. In so doing, the shoulder 170 abuts the upper edge 160 and presses the lateral liner portion 162 firmly into the lateral borehole. The outer diameter of the second component 154 is substantially identical to the inner diameter of the tubular element 158. Also, the outer diameter of the tubular element 158 is substantially identical to the inner diameter of the main borehole casing. Thus, the presence of the second component 154 adjacent the main borehole window ensures that the tubular element 158 is pressed firmly against the internal surface of the casing. Indeed, the tubular element 158 is firmly squeezed between the second component 154 and the main borehole casing so as to provide a good seal about the main/lateral junction.

As the second component 154 aligns with the main borehole window, the seal sub 180 locates in a Polished Bore Receptacle (PBR) secured below the window within the main borehole.

It may be preferable to run the flange liner 150 downhole without a full length of lateral liner tubing attached to the lateral liner portion 162. This may be the case even though said liner tubing is provided with one or more flex joints. It may

therefore be desirable to provide the downhole end of the lateral liner portion 162 with an inwardly projecting flange (i.e. a landing profile). The liner 150 may then be located in a main borehole window prior to the running of a lateral liner tubing through the lateral liner portion 162. The lateral liner tubing may be provided with a profile for making with the flange on the lateral liner portion 162.

A fifth embodiment of the present invention is shown in Figures 10 and 11. The fifth flange liner 200 is identical to the fourth flange liner 150 except for the provision of a landing profile 202 (as mentioned above) on the downhole end of the lateral liner portion 204, the provision of a ring seal element 205 (as described in relation to the second flange liner 112 of Figure 6) and the provision of a guide pin/slot system for ensuring the correct orientation of the first discrete component 206 relative to the second discrete component 208. The guide pin/slot system comprises two elongate slots 210 (only one of which is visible in the view of Figure 10) along a length of the second component 208. The guide system further comprises two guide pins 212 projecting from the inner surface of the uphole end of the tubular element 214. In use, the fifth flange liner 200 is run in whole with the two guide pins 212 slidably located in the elongate slots 210. Thus, the guide pin/slot system allows relative axial movement between the first and second discrete components 206, 208 without relative rotational movement therebetween (see Figures 12 and 13). In an alternative arrangement, guide slots may be provided in the tubular element 214 with cooperating guide pins being provided on the second discrete component 208.

As described in relation to the fourth flange liner 150, the uphole end of the second component 208 is provided with anchor means 216 and seal means 218.

A schematic internal view of the fifth flange liner 200 is shown in Figure 11. It will be seen that the interior of the second discrete component 208 comprises an internal latch profile 220 at a downhole end thereof for receiving a deflector 222. In use, the deflector 222 is employed to deflect the subsequently run lateral liner tubing into the lateral borehole. The lateral liner tubing is preferably conveyed in whole with an acidizing string made up internal to said liner. The acidizing string is provided with wrapped screens such that acidizing of formation can be carried out concurrently. The use of an acidizing string can be adapted to use with all the flange liners mentioned herein. Once the lateral liner tubing has been located

within the lateral borehole, the acidizing string may be retrieved and the deflector 222 recovered from the flange liner 200 so as to allow full access to the main borehole below the main/lateral junction.

Where size is not a constraint, the lateral borehole need not be drilled immediately after cutting the main borehole window and subsequently milling rat hole (i.e. a pilot hole). Instead, the flange liner 200 may be deployed as previously described and the lateral borehole drilled off the deflector 222. The completion string i.e. the lateral liner tubing) and acidizing string may then be run into the lateral borehole. The acidizing string, deflector 222 and any debris barrier may then be recovered.

The aforementioned flanged liners may be used with main borehole windows having standard geometries (for example, the casing window 14 shown in Figure 3). Such windows may include Widetrack, Gauge Max, and possibly even Extended Gauge, all being predominantly variations on Trackmaster windows produced using multi-ramp whipstock profiles. The most appropriate form of window may be one which is an extended gauge widetrack. Such a window comprises a standard cut out, extended widetrack (maximum width section as produced with Gauge Max, but having a shorter length) and a runout which causes tapering at the bottom of the window, but which allows mill exit into formation when cutting a rat hole (i.e. a pilot hole for the drilling assembly).

A casing window particularly suited to use with the aforementioned flange liners is shown in Figures 14 and 15 of the accompanying drawings. Using a Trackmaster mill 300 and whipstock 302 system having controlled gauge, it is possible to provide a window 304 having a maximum width 306 substantially equal to the mill 300 maximum diameter for the majority of the window length. This window profile is achieved by the whipstock 302 having a concave height which remains essentially constant. As a result, the mill 300 travels from adjacent the top of the window to adjacent the bottom of the window whilst cutting with its maximum diameter. This may be contrast with the prior art hook hanger system wherein the maximum width of the window 14 extends over a very short length. Consequently, the location of the maximum window width is more difficult to predict in the prior art system and complicates installation of the completion assembly.

With the window profile shown in Figures 14 and 15, it is possible to drill off the whipstock 302 into the surrounding formation - not having exited into the formation with the mill 300 when cutting the window 304. Drilling of the concave would necessitate use of a directional motor with a bent housing orientated to drive the drilling bit into the formation. Alternatively, a drilling bit could be deflected into the formation using a deflector which has been installed so as to replace the whipstock 302 used to mill the window 304. As a further alternative, the whipstock 302 could be anchored uphole of the position shown in Figure 14 so that the lowermost ramp 308 of said whipstock 302 can be used to deflect the drilling bit through the window 304.

A completion process chart is provided in Figure 16 of the accompanying drawings wherein the steps to be taken in completing a natural borehole (leg 2) with an undercut (without a bent joint) or without an undercut (with a bent joint) are indicated. The concurrent running of a lateral tubing string 400 and the first flange liner 100 through a window 402 provided in a main borehole casing 404 (between the dotted lines labelled with reference numeral 406) is shown in the queue sequences of Figures 17 to 19 and Figures 20 to 21. The first sequence shown in Figures 17 to 19 relate to the completion of lateral borehole with no undercut (i.e. through use of a bent joint). The second sequence shown in Figures 20 to 21 show the completion of a lateral borehole with an undercut (i.e. through use of a deflector 408). In each sequence, the flange liner 100 is connected to the lateral liner tubing 400 by means of a flex joint 410.

The completion operations summarised in the aforementioned two sequences make use of a widetrack whipstock. A plan view of the deflecting surface of said widetrack whipstock 412 is shown in Figure 22 wherein the location of the cut window 402 in relation to a fully deployed flange liner 100 is shown by means of the aforementioned dotted lines 406. Cross-sectional views of the flange liner 100 at various longitudinal positions along its length are also shown in Figure 22 wherein the lateral position of said flange liner relative to the longitudinal axis 414 of the casing 404 is presented. By way of contrast, Figure 23 shows a gauge max whipstock 416 with the associated window and flange liner 100 positions being indicated by the aforementioned dotted lines 406. It will be appreciated that the dotted lines 406 relate to a different window to the window 402 referred to in respect of Figures 17 to 22.

Cross-sectional views of the flange liner 100 are also shown in Figure 23 in a similar manner as shown in Figure 22. A sixth embodiment 500 of the present invention is shown, in part, in Figures 24 and 25. The sixth flange liner 500 is identical to the fifth flange liner 200 except that the lateral liner portion 502 is formed in a collapsed state so as to allow the flange liner to locate within the main borehole casing. It will be noted that Figures 24 and 25 merely show a first discrete component 504 for replacing the first discrete component 206 of the fifth flange liner 200. A second discrete component (corresponding to the second discrete component 208 of the fifth flange liner 200) in respect of the sixth flange liner 500 is not shown in Figures 24 and 25.

The collapsed lateral liner portion 502 may be resiliently deformed as shown in Figures 24 and 25 so that the illustrated deformed shape is retained by means of lateral force applied by the chasing of the main borehole. Thus, in these circumstances, once the first discrete component 504 locates adjacent the main borehole chasing, the lateral liner portion 502 will tend to spring back to its original tubular shape. In this regard, the lateral liner portion 502 may be manufactured from titanium or any suitable alloy. Alternatively, the collapsed lateral liner portion 502 may be reformed into a tubular shape by mechanical, hydraulic, explosive or any other suitable means.

The present invention is not limited to the specific embodiments and methods described above. Alternative arrangements and suitable materials will be apparent to the reader skilled in the art. For example, any one of the aforementioned flange liners may be used in conjunction with a main borehole casing which has been provided with an eccentric joint. Such an arrangement is shown in Figures 26 and 27 wherein the fourth flange liner 150 is run through a portion of main borehole casing having two overlapping internal diameters 602, 604.

Inventor comments in respect of the system shown in Figures 26 and 27 are as follows:

Provide a joint of casing shaped like a gas lift mandrel (25 to 30 feet in length). The window would be created or, better still preformed, at the lower most end of the eccentric part of the joint. There would be a MOLE like profile sub run below this joint for a depth and orientation datum point. The top most part of the

eccentric joint would house a sliding sleeve 154 with a preformed window 166 in it just slightly larger than the main borehole window.

Operation would be as follows -

1) Drill 8½" hole or larger to depth.

2) Run 7" casing with one or more Gas lift mandrel shaped eccentric joints (EJ) with MOLE equivalent profile subs below each joint.

3) Orientate the EJ's to the desired azimuth (preferably high side).

4) Cement the casing string in place (the ID and the EJ would be lined with a compound that could be jetted away with a jet wash tool).

5) Run the jet wash tool to remove the lining (perhaps even an acid soluble lining).

6) Run the whipstock/deflector and latch into the MOLE sub, set the packstock and drill ahead to depth.

7) Run the lateral to completion with the saddle 152 and land off. The running tool must extend into the lateral liner and it must have a hydraulic and/or mechanical release mechanism so that is can withstand pushing and pulling to get the completion to bottom. A telescopic joint with a lock ring assembly above where the running tool locates may be used. Once the completion is landed and the running tool is released, pick up and use the completion running tool to close the telescopic joint and drive home the saddle 152.

8) Once the saddle 152 is seated, pull out of the hole and run in with a tool to engage the sliding sleeve 154 and force it down to sandwich the saddle. The bottom of the sleeve may incorporate a latch to lock it into position.

9) Move up and do the next lateral borehole.

CLAIMS:

1. Downhole apparatus for sealing a junction between a main borehole and a lateral borehole, the apparatus comprising a tubular liner portion for lining a portion of a lateral borehole adjacent an opening of a main borehole into the lateral borehole, an end portion of said tubular liner portion being provided with a flange element having a curved surface for locating in abutment with an area of main borehole surrounding said opening.

2. Downhole apparatus as claimed in claim 1, wherein said curved surface is part cylindrical.

3. Downhole apparatus as claimed in claim 1 or 2, wherein said flange element is elongate in shape and one end thereof is cylindrical.

4. Downhole apparatus as claimed in claim 3, wherein said cylindrical end comprises a part spherical portion.

5. Downhole apparatus as claimed in claim 3 or 4, wherein said cylindrical end is spaced from said tubular liner portion.

6. Downhole apparatus as claimed in claim 2, wherein said flange element is elongate in shape and one end thereof is provided with an edge profile, said downhole apparatus further comprising a cylindrical member having a projection for abutment with said edge profile.

7. Downhole apparatus as claimed in claim 6, wherein said cylindrical member is provided with an aperture in the side thereof, said aperture being positioned so as to align with said tubular liner portion when said projection and edge profile are in abutment.

8. Downhole apparatus as claimed in claim 7, wherein the exterior surface of said cylindrical member about said aperture is provided with a seal element.

9. Downhole apparatus as claimed in any of claims 6 to 7, wherein said flange element is secured to said cylindrical member by means for permitting relative axial movement between said flange element and said cylindrical member without relative rotational movement therebetween.

10. Downhole apparatus as claimed in claim 9, wherein said means comprises a pin slidably located in a slot.

11. Downhole apparatus as claimed in claim 10, wherein said pin is provided on said flange element and said slot is provided on said cylindrical member.

12. Downhole apparatus as claimed in any of claims 9 to 11, wherein said means for permitting relative axial movement permits movement of said flange element from a first position, wherein the longitudinal axis of said tubular liner portion is substantially in line with the longitudinal axis of said cylindrical member, to a second position, wherein said edge profile and shoulder are in abutment and the longitudinal axis of said tubular liner portion extends at an angle to the longitudinal axis of said cylindrical member.

13. Downhole apparatus as claimed in any of the preceding claims, wherein the exterior surface of said flange element about said tubular liner portion is provided with a seal element.

14. Downhole apparatus as claimed in any of the preceding claims, wherein said tubular liner portion comprises folded side walls so that, when unfolded, said tubular liner portion has a circular cross-section, and, when folded, said tubular liner portion has a cross-sectional area of less magnitude than the area of said circular cross-section.

15. A method of sealing a junction between a main borehole and a lateral borehole, the method comprising the steps of running the apparatus of any of the

preceding claims down a main borehole and locating the tubular liner portion within a lateral borehole.

16. A method as claimed in claim 15, the method comprising the further step of pressing the flange element into abutment with an area of main borehole surrounding an opening of the main borehole into the lateral borehole.

17. A method as claimed in claim 16, wherein said flange element is pressed by means of a cylindrical member.

18. A method as claimed in any of claims 15 to 16, the method comprising the step of expanding said tubular liner portion from a folded condition to an unfolded condition in which said tubular liner portion is generally cylindrical in shape.

19. A method as claimed in any of claims 15 to 17, wherein said tubular liner portion is folded prior to running said apparatus down the main borehole.

Fig.1.
PRIOR ART.

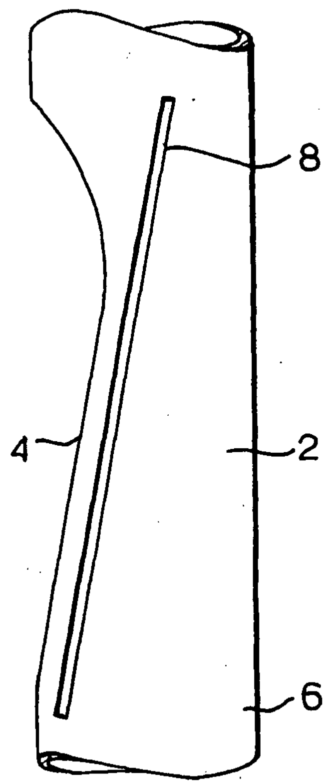


Fig.2.
PRIOR ART.

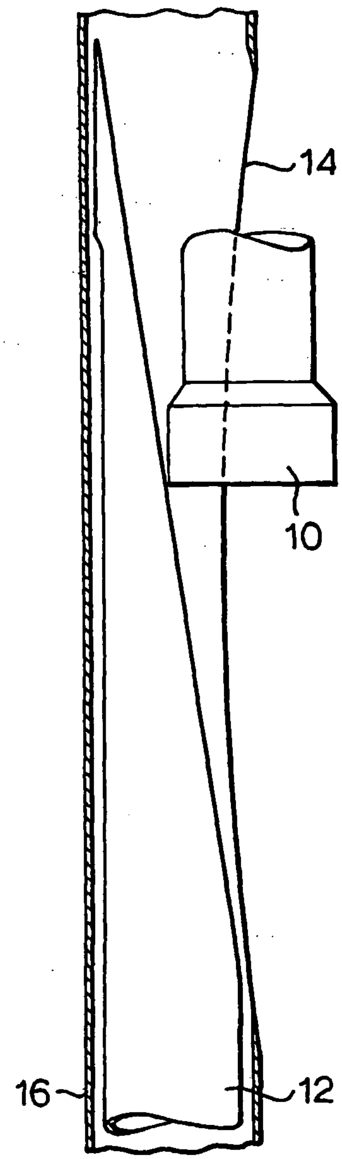


Fig.3.
PRIOR ART.

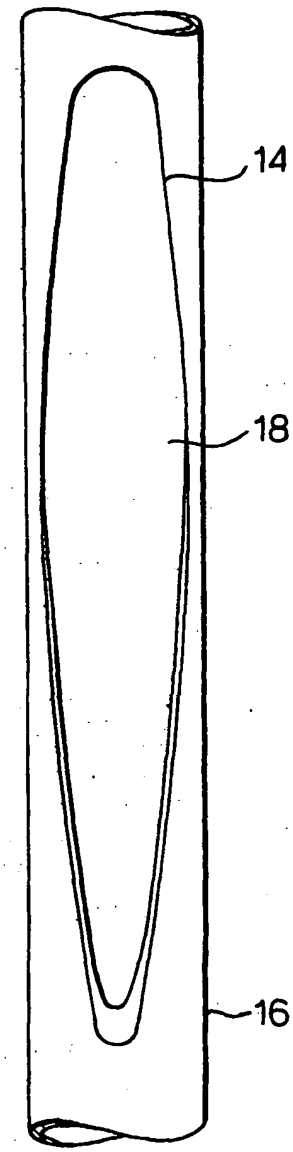


Fig.4.

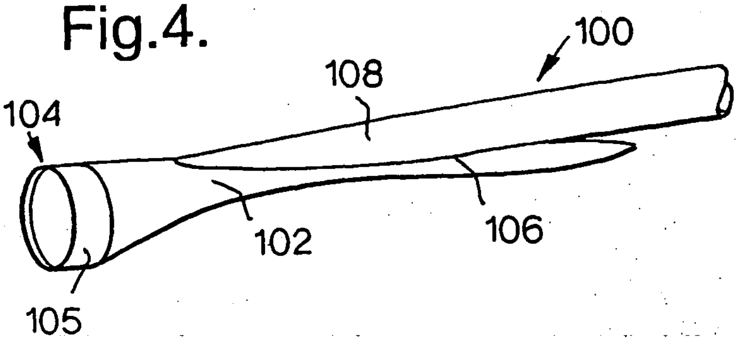


Fig.5.

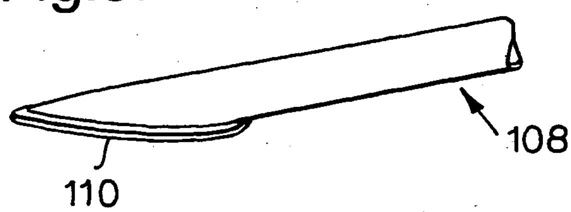


Fig.6.

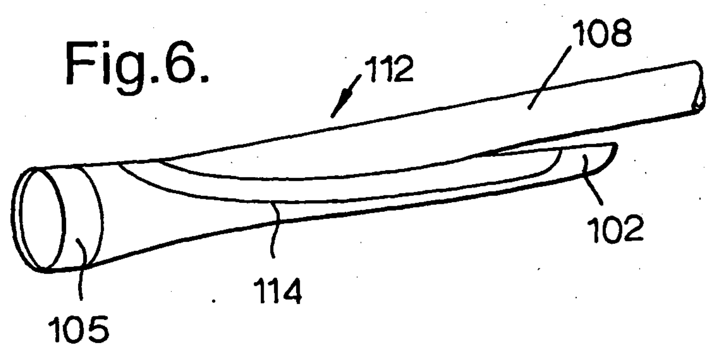


Fig.7.

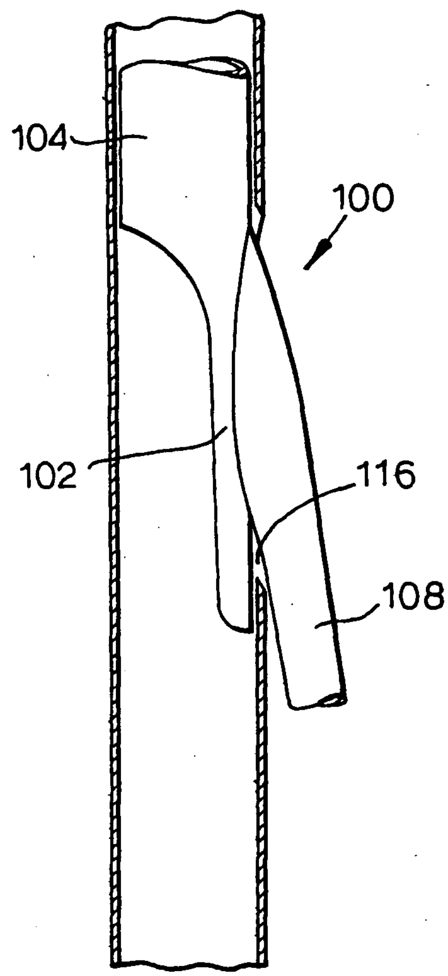


Fig.8.

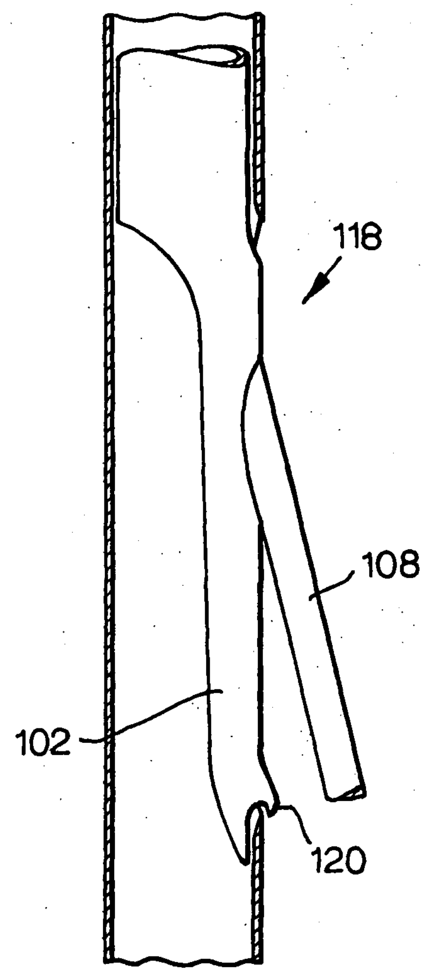


Fig.9.

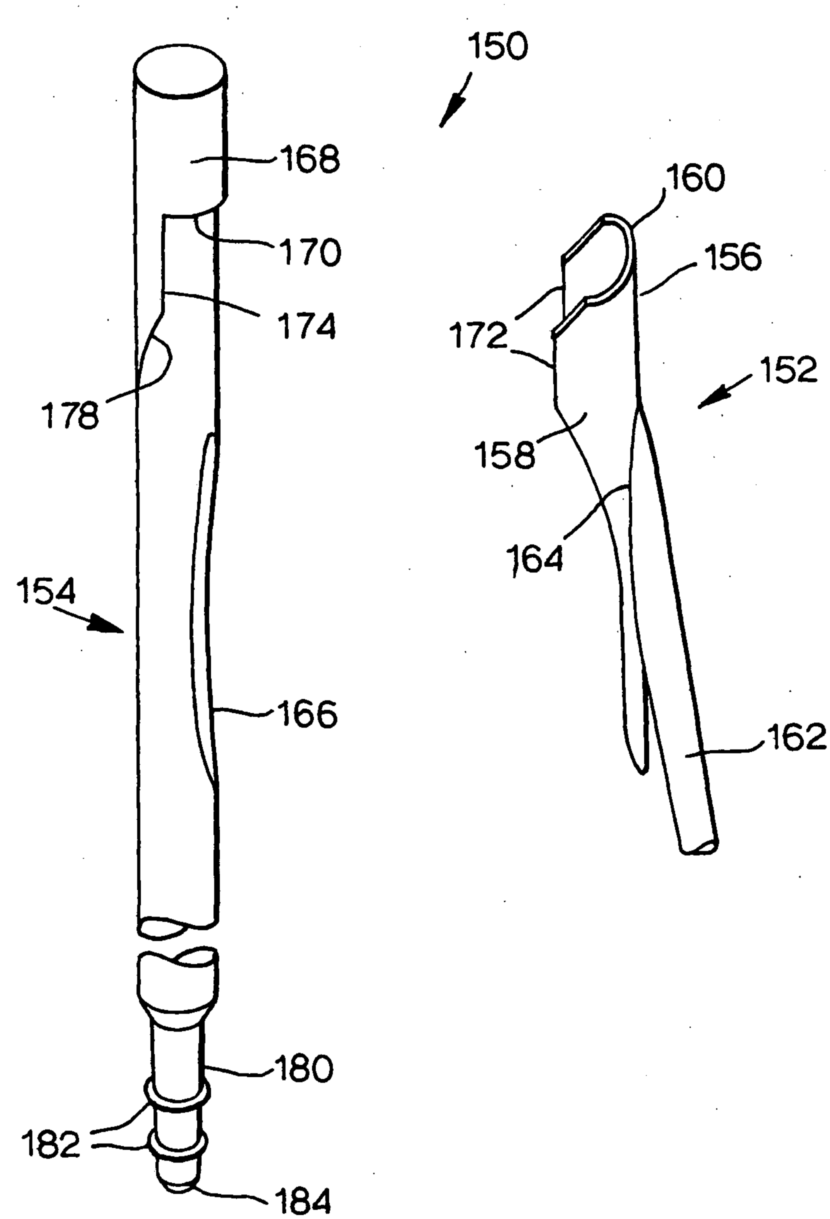

150
168
170
174
178
154
166
180
182
184
160
156
172
152
158
164
162

Fig.10.

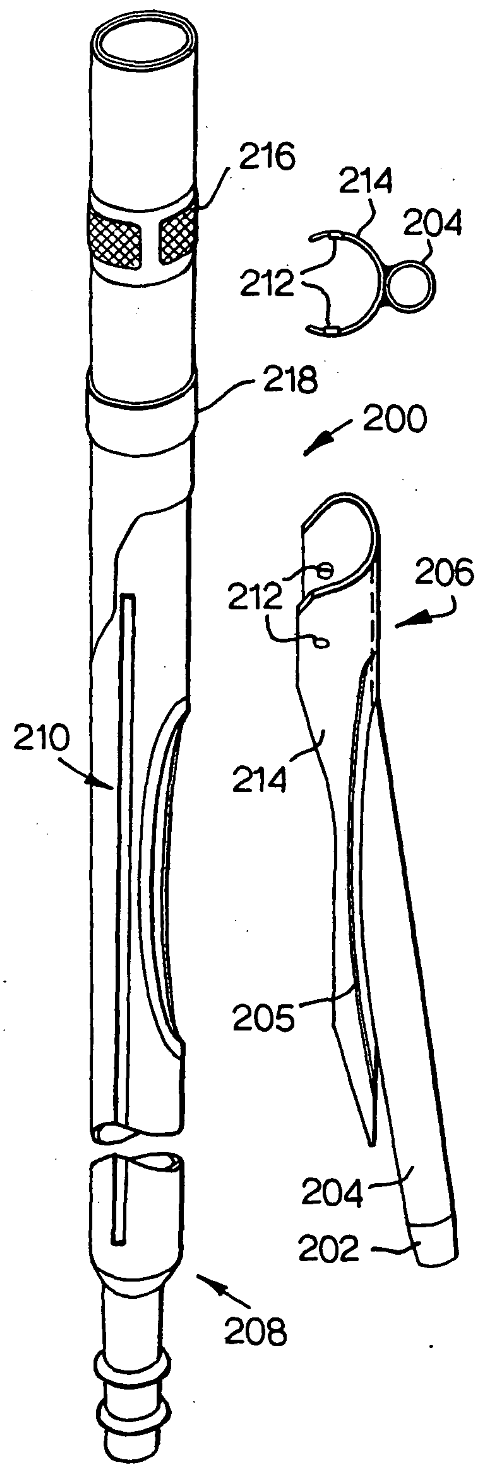


Fig.11.

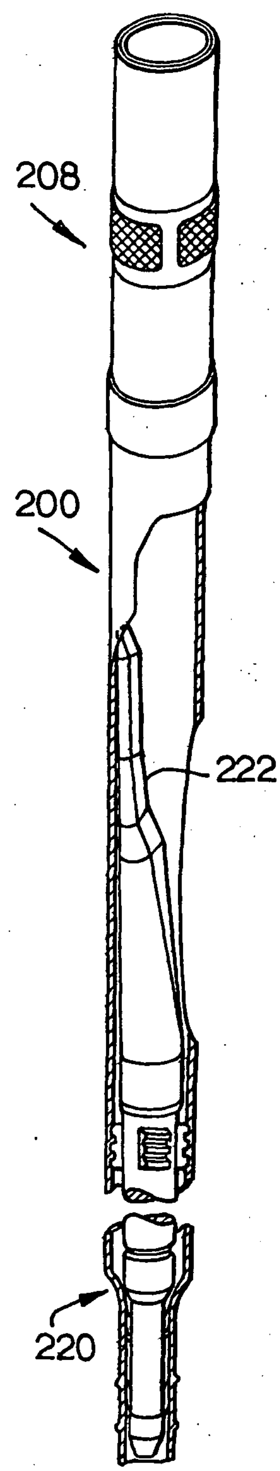


Fig.12.

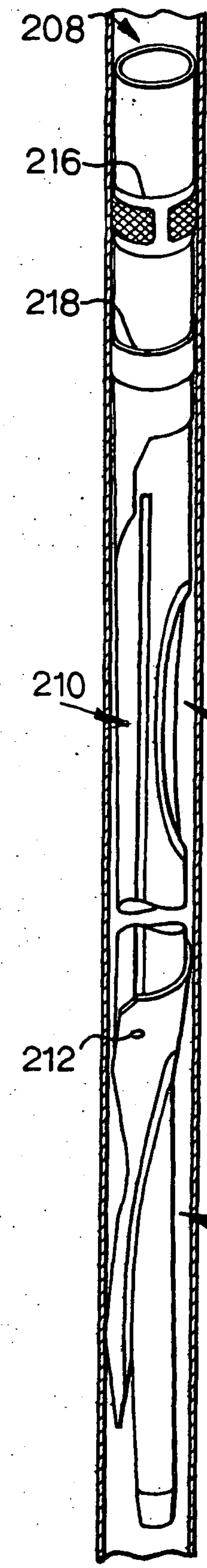


Fig.13.

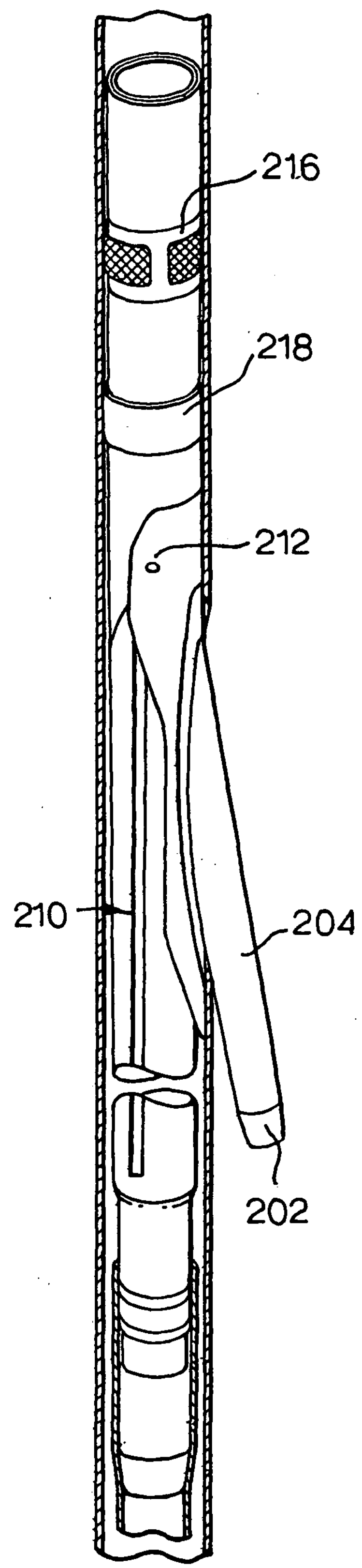


Fig.14.

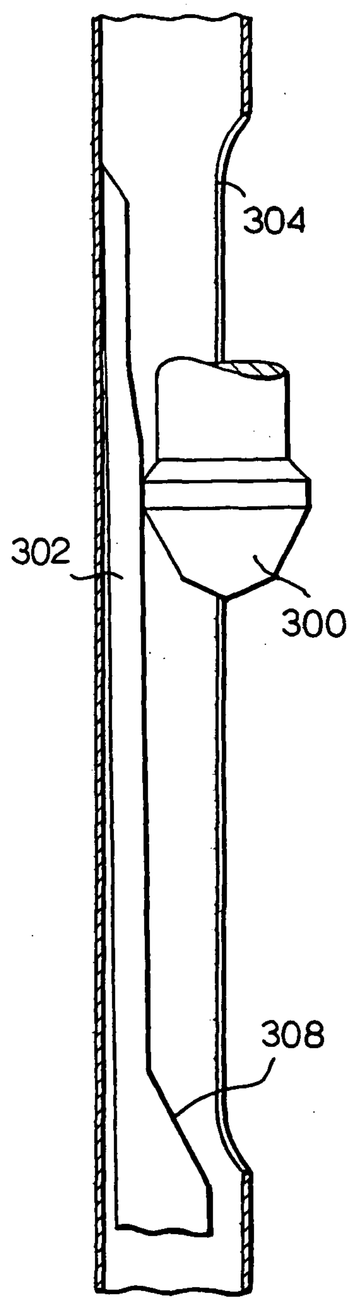
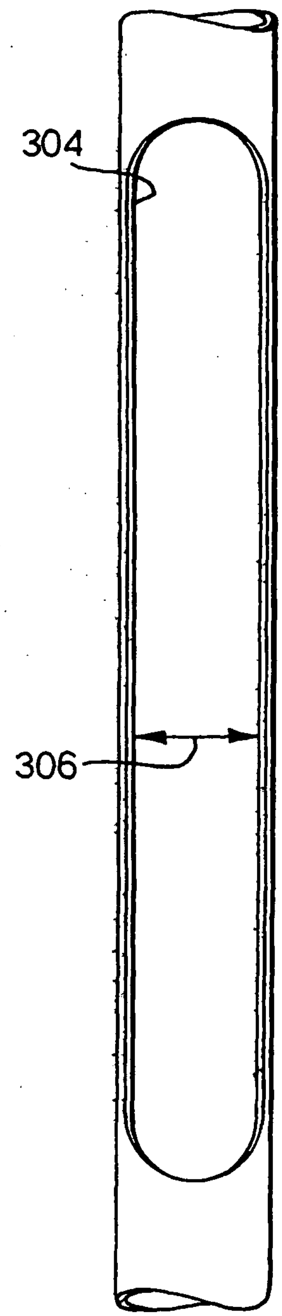


Fig.15.



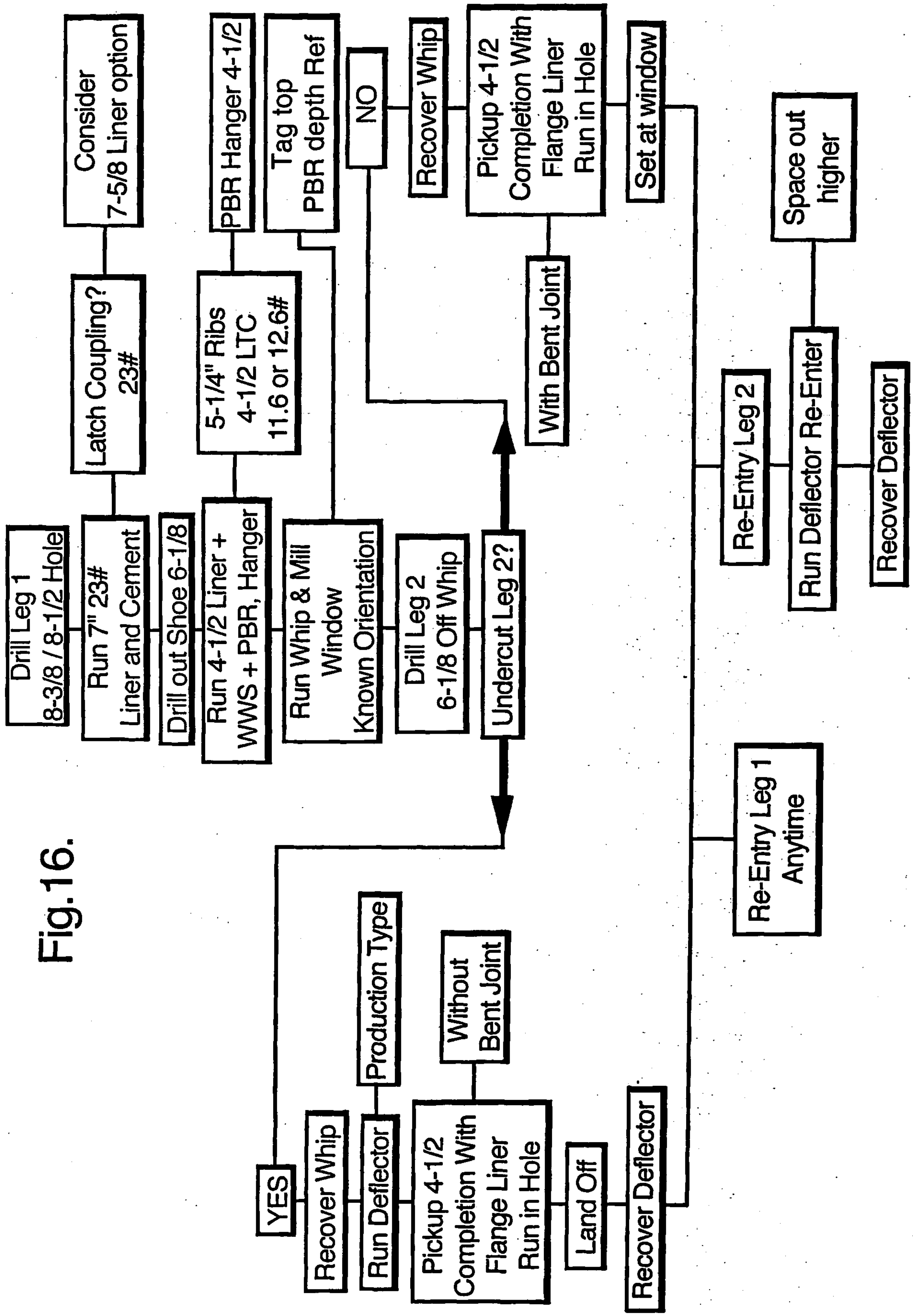

Drill Leg 1
8-3/8 / 8-1/2 Hole
Run 7" 23#
Liner and Cement
Latch Coupling?
23#
Consider
7-5/8 Liner option
Drill out Shoe 6-1/8
Run 4-1/2 Liner +
WWS + PBR, Hanger
5-1/4" Ribs
4-1/2 LTC
11.6 or 12.6#
PBR Hanger 4-1/2
Run Whip & Mill
Window
Known Orientation
Tag top
PBR depth Ref
Drill Leg 2
6-1/8 Off Whip
Undercut Leg 2?
NO
Recover Whip
Pickup 4-1/2
Completion With
Flange Liner
Run in Hole
With Bent Joint
Set at window
Re-Entry Leg 2
Run Deflector Re-Enter
Space out
higher
Recover Deflector
Re-Entry Leg 1
Anytime
YES
Recover Whip
Run Deflector
Production Type
Pickup 4-1/2
Completion With
Flange Liner
Run in Hole
Without
Bent Joint
Land Off
Recover Deflector

Fig.16.

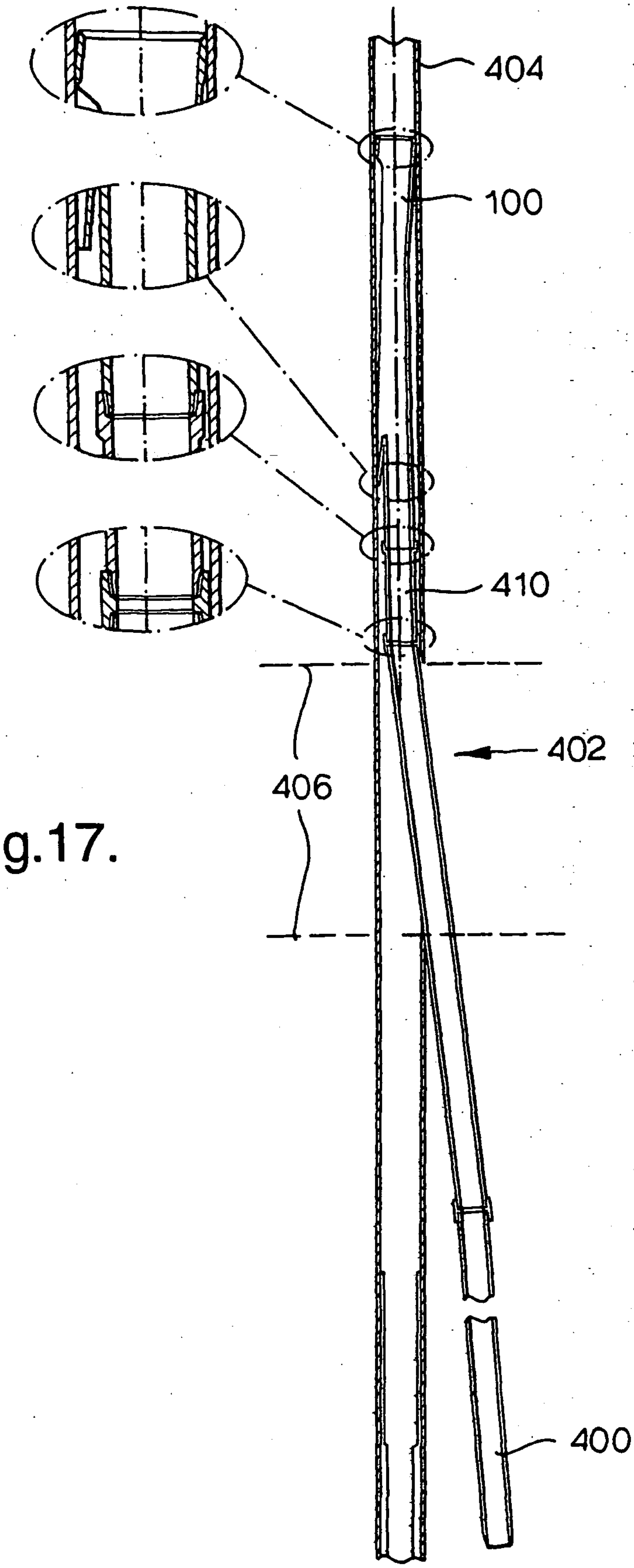


Fig.17.

Fig.18.

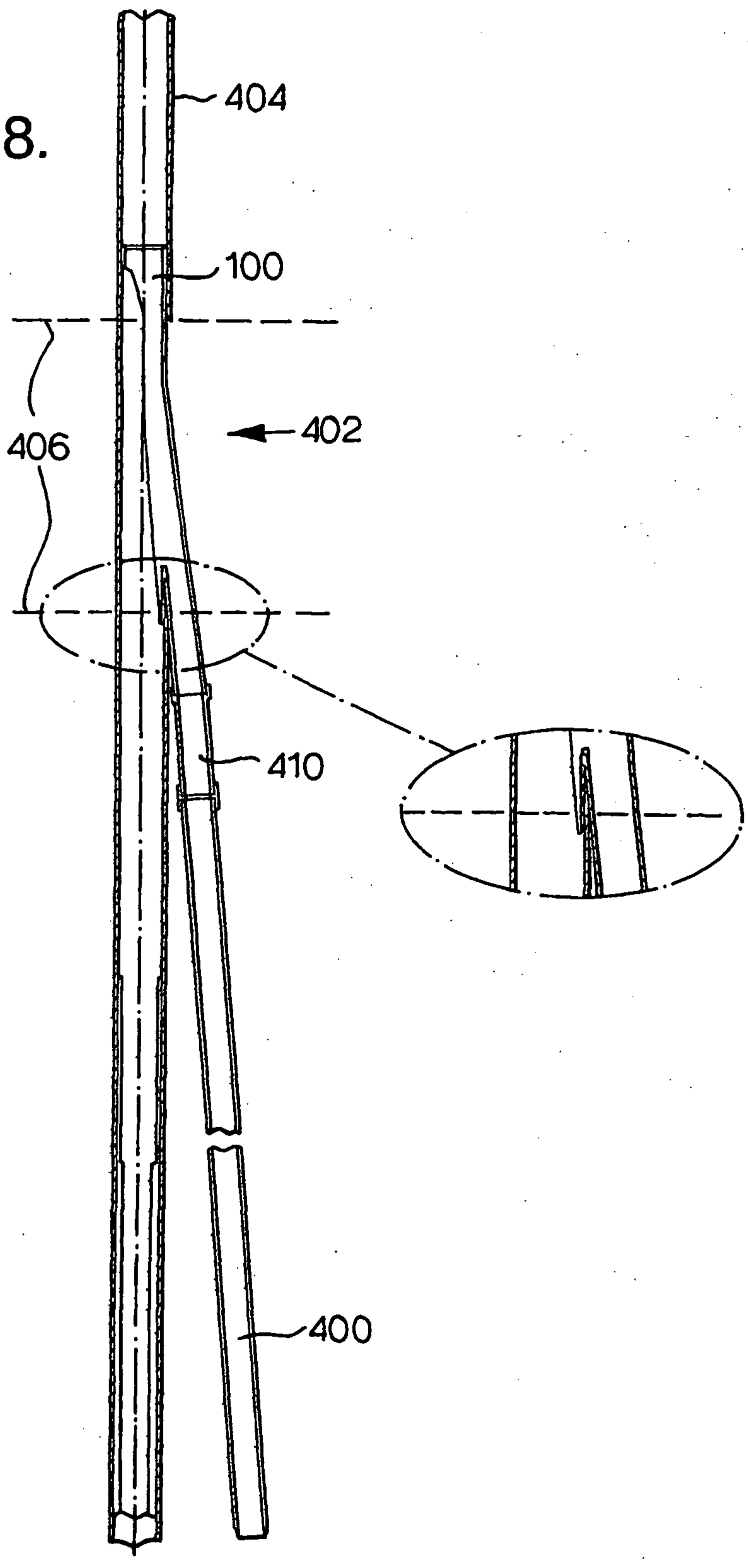
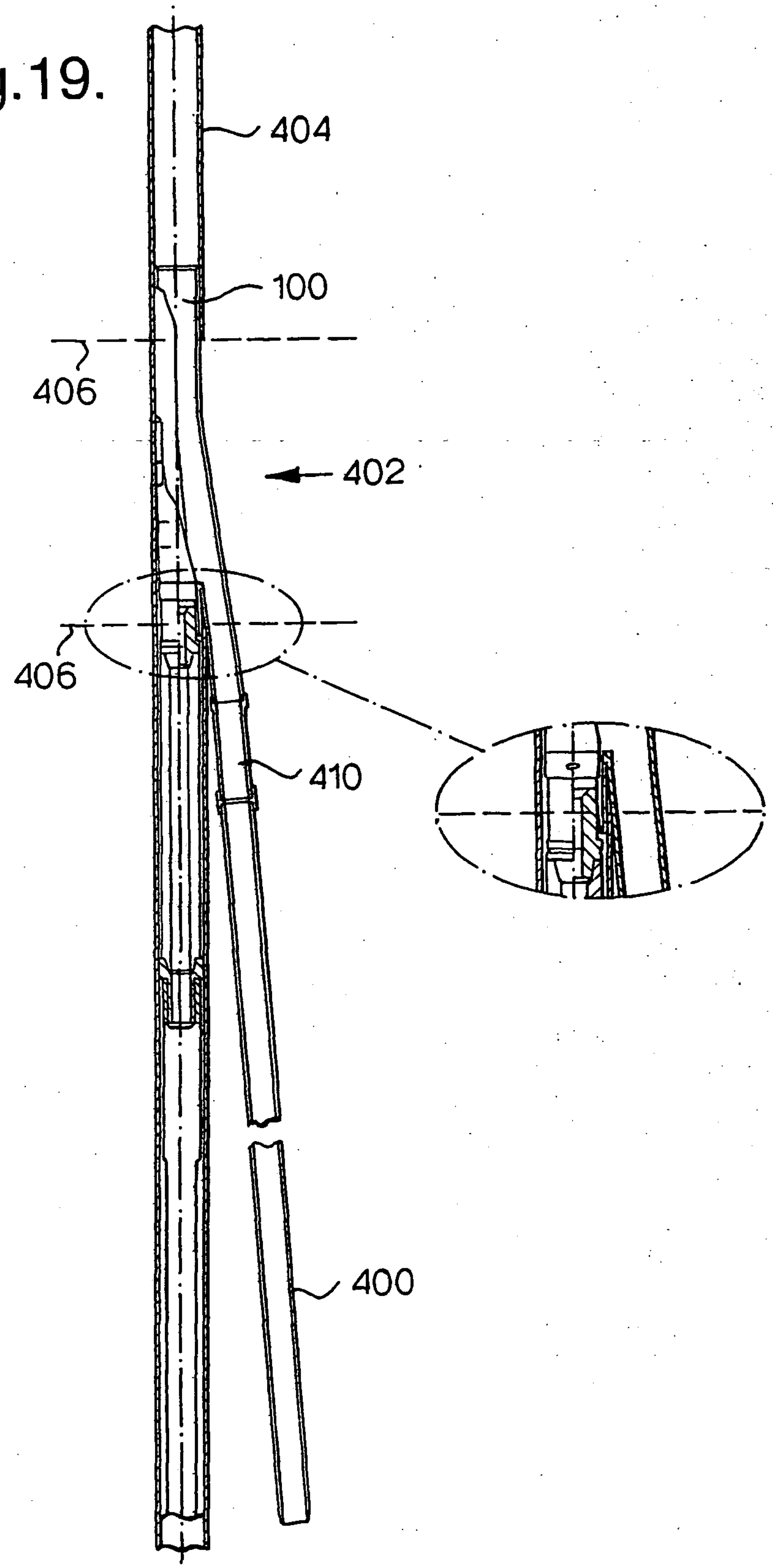


Fig.19.



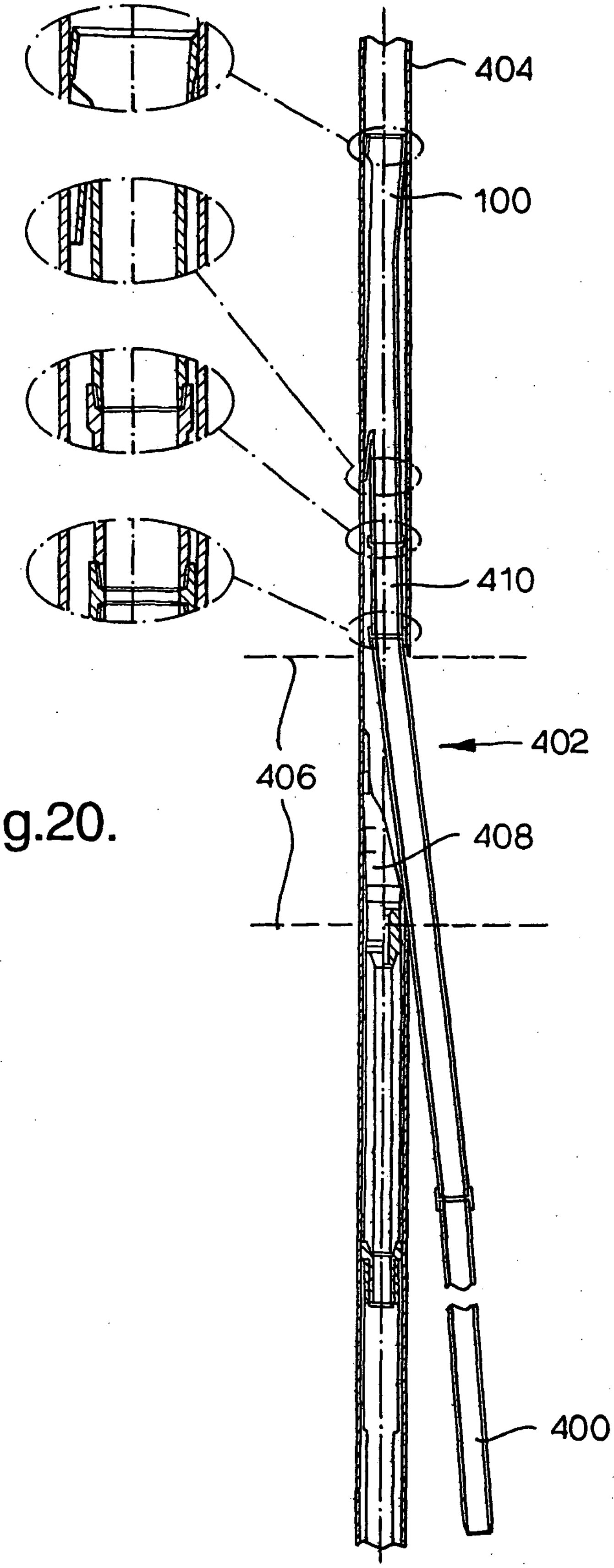


Fig.20.

Fig.21.

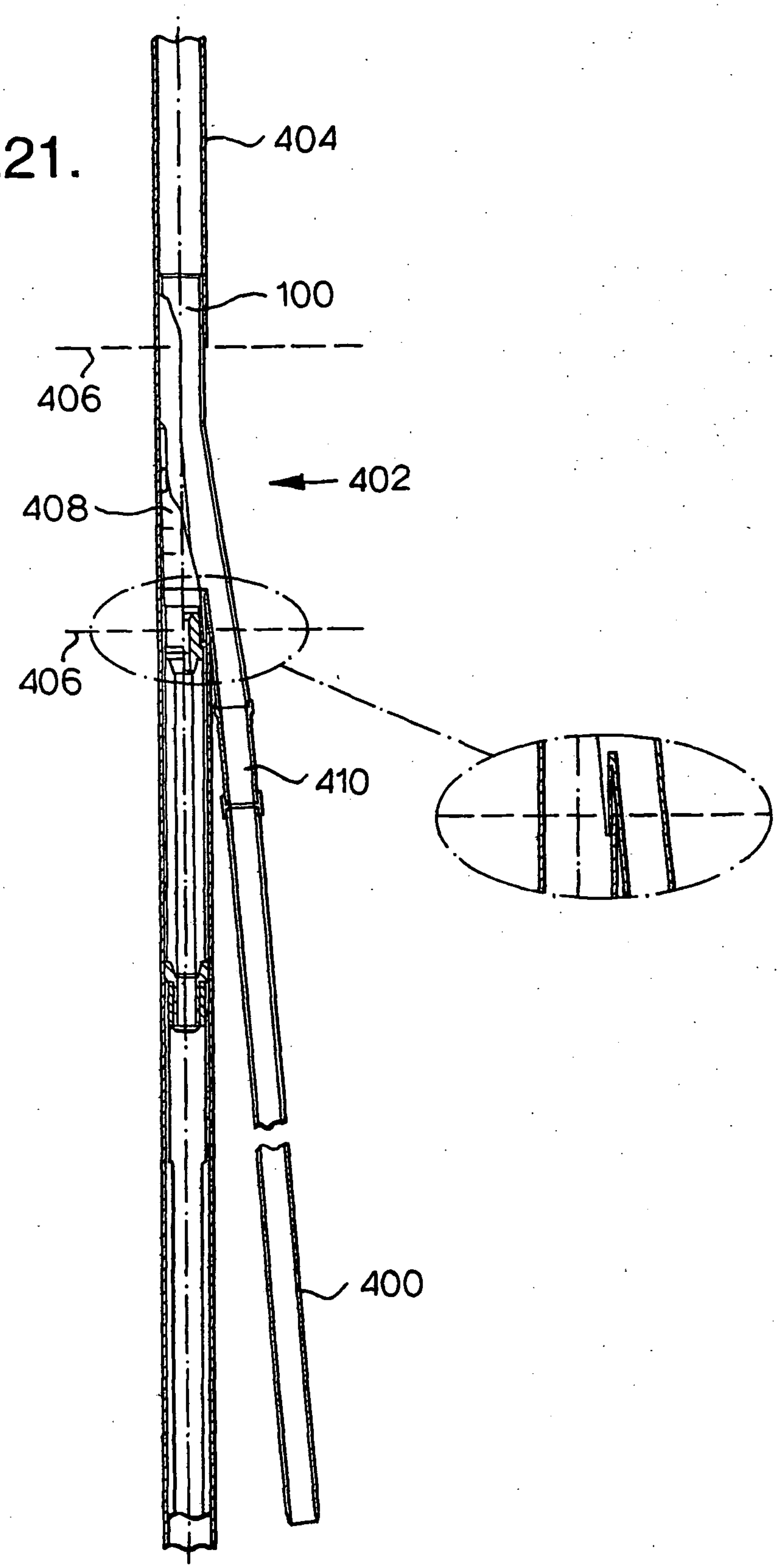


Fig.22.

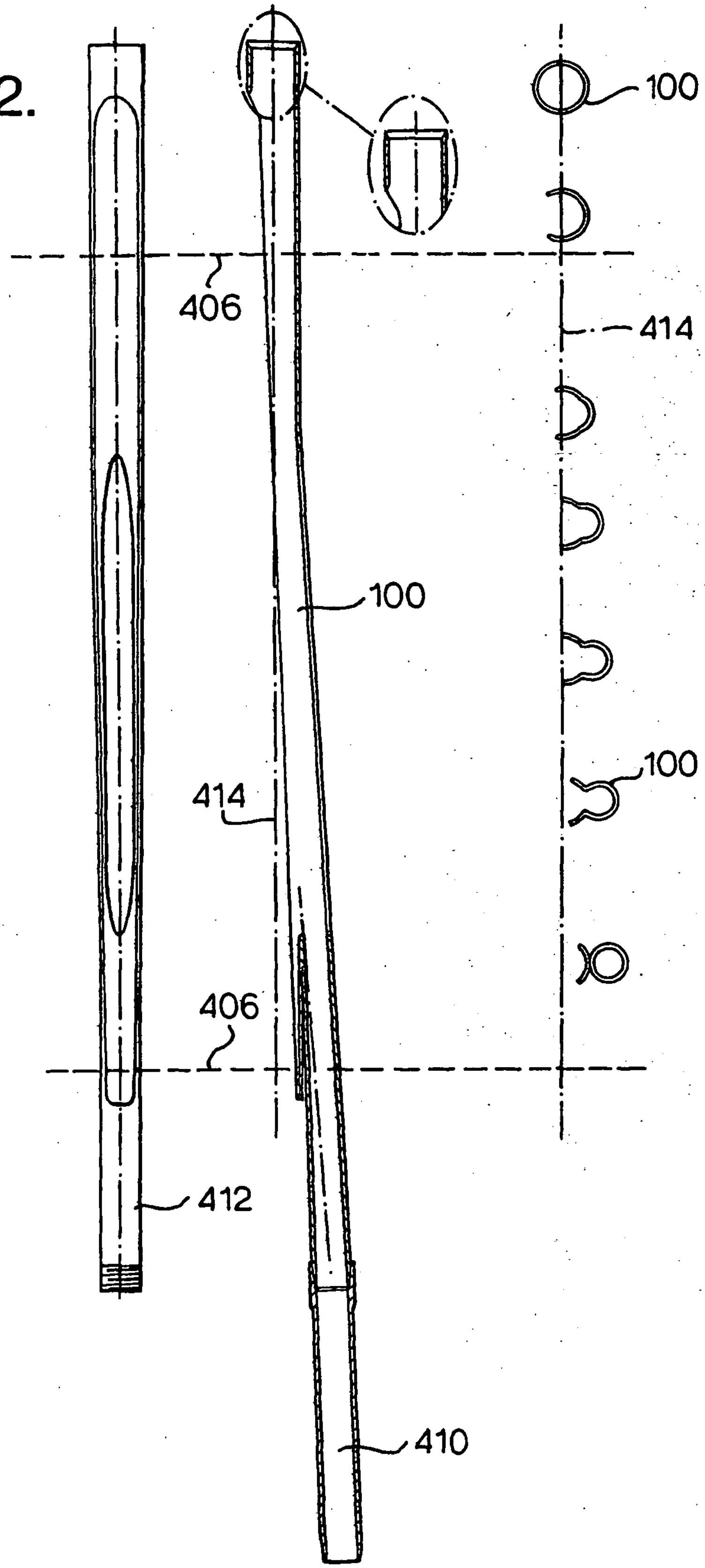


Fig.23.

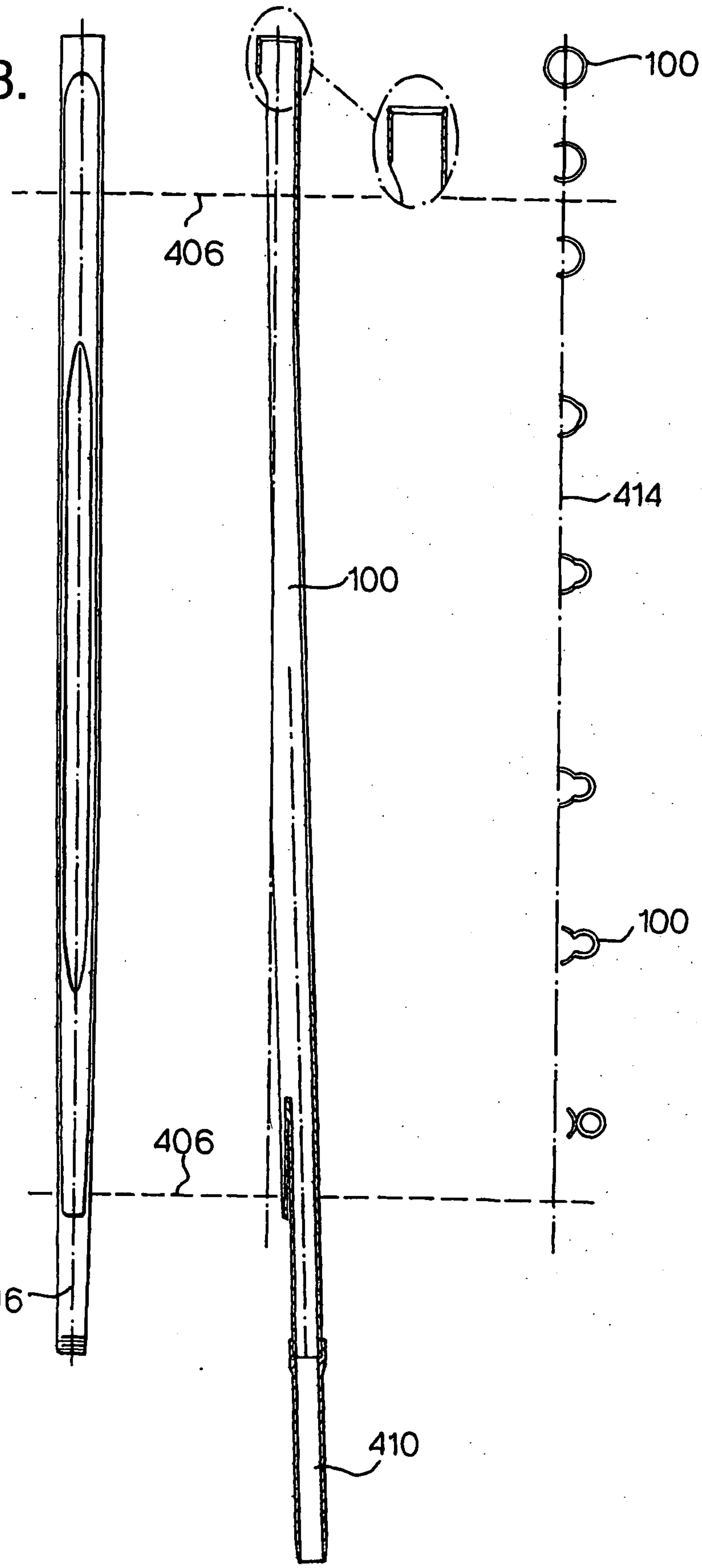


Fig.24.

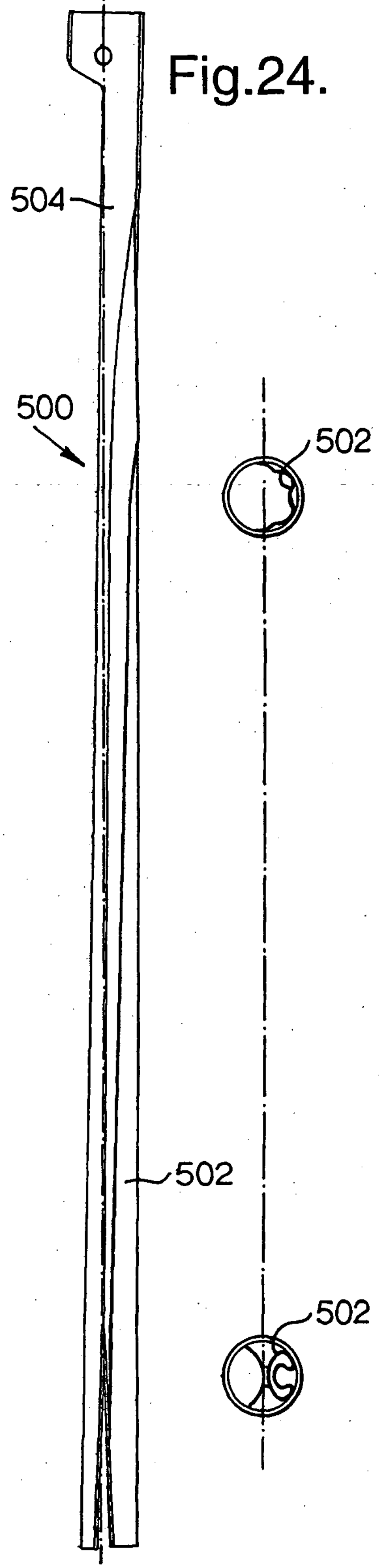


Fig.25.

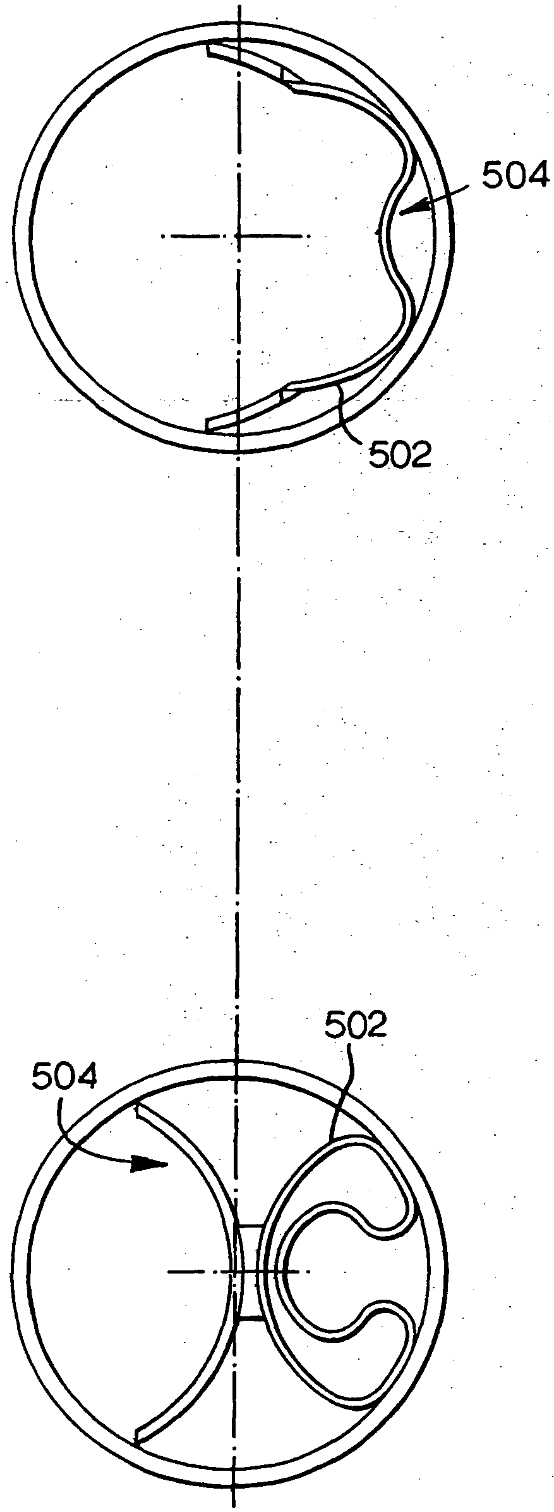


Fig.26.

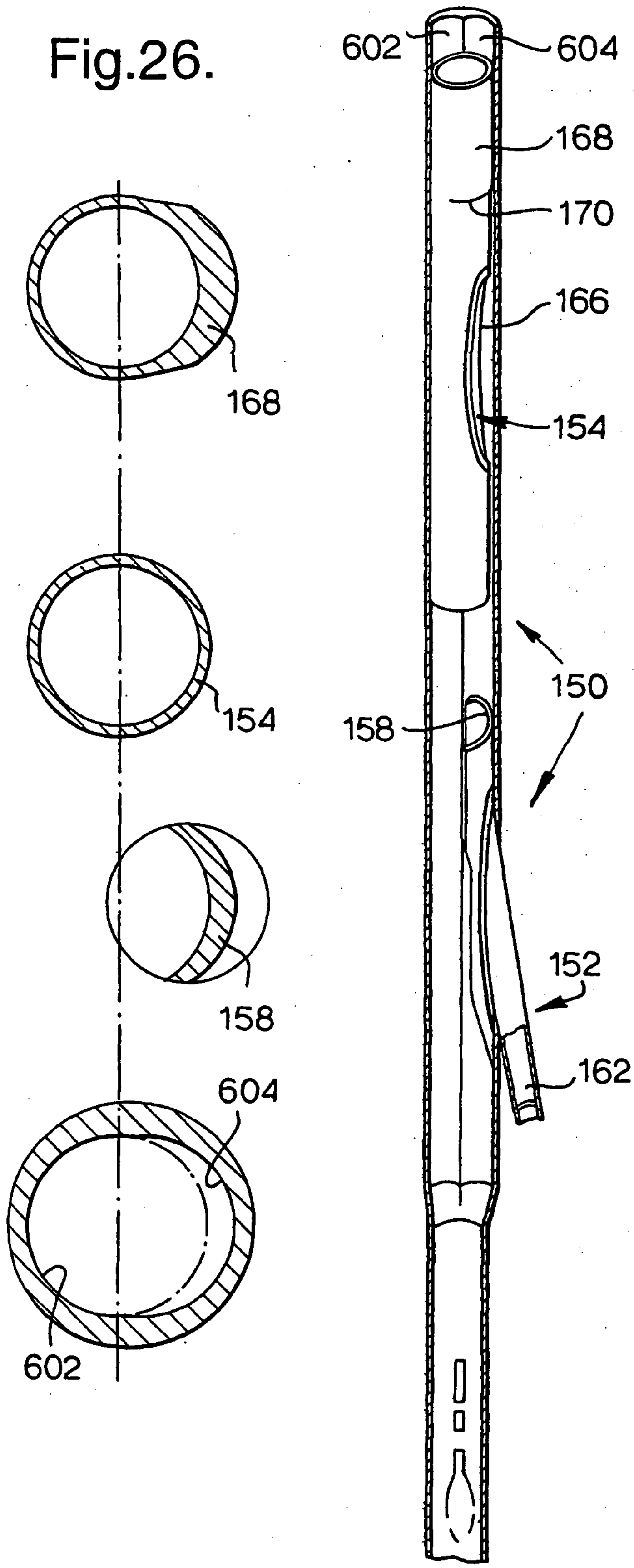
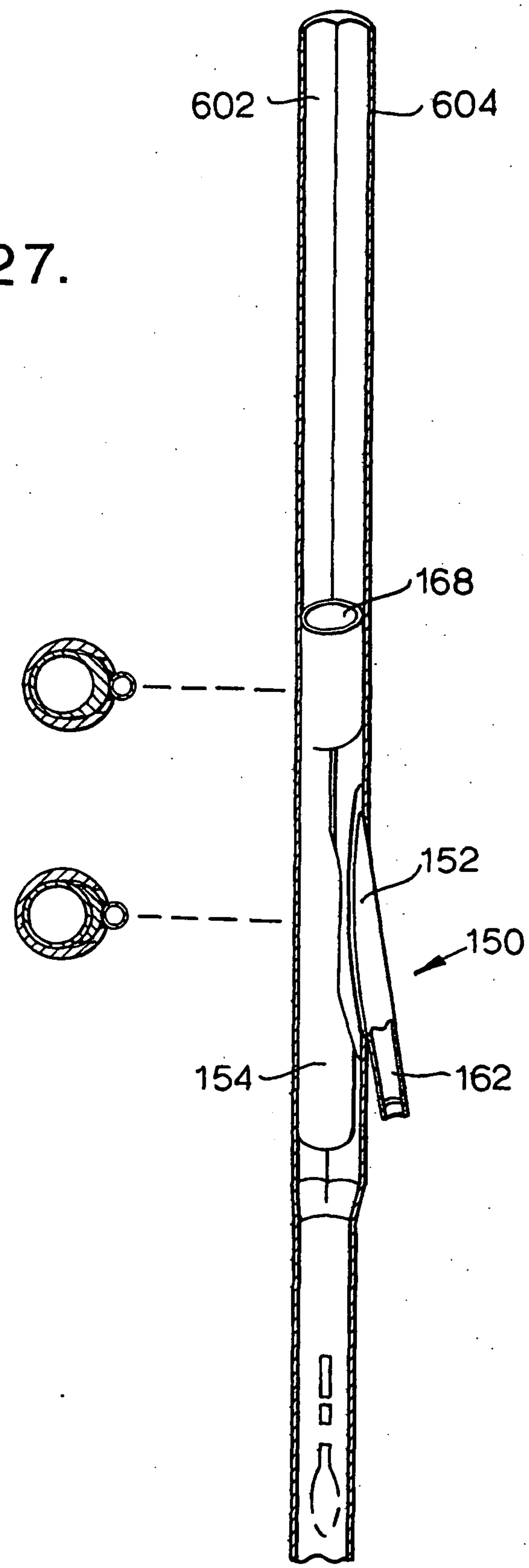


Fig.27.



INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 01/02283

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E21B41/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 012 526 A (JACKSON JAMES K ET AL) 11 January 2000 (2000-01-11) column 8, line 45 -column 9, line 15; figures 4-10	1-8,13, 15-17
Y	column 5, line 23-56	9-11,14, 18,19
X	US 5 388 648 A (JORDAN JR HENRY J) 14 February 1995 (1995-02-14) column 8, line 3-40; figure 3	1-3,6-8, 13,15-17
X	US 5 735 350 A (MILLS DAVID H ET AL) 7 April 1998 (1998-04-07) column 16, line 19-65; figure 4	1-3,6-8, 13,15-17

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 August 2001	12/10/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	van Berlo, A

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 012 516 A (BRUNET CHARLES G) 11 January 2000 (2000-01-11) column 6, line 20-29	1-3,6,7, 13,15,17
A	column 6, line 53 -column 9, line 57; figures 1-3,8	9-12
Y	US 6 062 306 A (DALE DANA R ET AL) 16 May 2000 (2000-05-16) column 4, line 39-49; figures 1,2,5,29 column 18, line 47 -column 19, line 42	9-11
Y	US 5 979 560 A (NOBILEAU PHILIPPE) 9 November 1999 (1999-11-09) figures 1-19	14,18,19
A	GB 2 327 964 A (PHILLIPS PETROLEUM CO) 10 February 1999 (1999-02-10) page 7, line 9-28; figures 1,2	9-12
A	J. LINDVALL ET AL.: "Multilateral Tieback Insert Povides a Low-Cost Sealing Multilateral Junction" SPE 57540, 8 November 1999 (1999-11-08), XP002175575 Abu Dhabi cited in the application figures 1-6	1
A	US 5 787 987 A (LURIE PAUL GEORGE ET AL) 4 August 1998 (1998-08-04) column 5, line 58 -column 6, line 2	1
A	GB 2 330 159 A (DRESSER IND) 14 April 1999 (1999-04-14) page 3, line 4-21	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int onal Application No
PCT/GB 01/02283

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 6012526	A	11-01-2000	AU	3418397	A	19-02-1998
			CA	2212923	A	13-02-1998
			GB	2353811	A,B	07-03-2001
			GB	2353812	A,B	07-03-2001
			GB	2353813	A,B	07-03-2001
			GB	2353814	A,B	07-03-2001
			GB	2316424	A,B	25-02-1998
			NO	973697	A	16-02-1998
			NO	20003937	A	16-02-1998
US 5388648	A	14-02-1995	CA	2133240	A	09-04-1995
			GB	2282835	A	19-04-1995
US 5735350	A	07-04-1998	US	5564503	A	15-10-1996
			CA	2156977	A	27-02-1996
			CA	2156981	A	27-02-1996
			CA	2156982	A	27-02-1996
			CA	2156983	A	27-02-1996
			CA	2156984	A	27-02-1996
			CA	2156987	A	27-02-1996
			EP	0701042	A	13-03-1996
			EP	0701044	A	13-03-1996
			EP	0701040	A	13-03-1996
			EP	0701045	A	13-03-1996
			EP	0701043	A	13-03-1996
			EP	0701041	A	13-03-1996
			NO	953303	A	27-02-1996
			NO	953304	A	27-02-1996
			NO	953323	A	27-02-1996
			NO	953324	A	27-02-1996
			NO	953325	A	27-02-1996
			NO	953326	A	27-02-1996
			NO	20001342	A	27-02-1996
			SG	32473	A	13-08-1996
			SG	34260	A	06-12-1996
			SG	32475	A	13-08-1996
			SG	32476	A	13-08-1996
			SG	34261	A	06-12-1996
			SG	32477	A	13-08-1996
			US	5507346	A	16-04-1996
			US	5499680	A	19-03-1996
			US	5501281	A	26-03-1996
			US	5499681	A	19-03-1996
			US	5566763	A	22-10-1996
			US	5613559	A	25-03-1997
US 6012516	A	11-01-2000	CA	2236047	A	05-03-1999
US 6062306	A	16-05-2000	BR	9900338	A	18-01-2000
			GB	2333545	A	28-07-1999
			NO	990359	A	28-07-1999
US 5979560	A	09-11-1999	AU	733469	B	17-05-2001
			AU	8880598	A	29-03-1999
			EP	1012441	A	28-06-2000
			WO	9913195	A	18-03-1999
			NO	20001148	A	07-03-2000
			US	6253852	B	03-07-2001

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte___nal Application No

PCT/GB 01/02283

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2327964 A	10-02-1999	WO 9857031 A	17-12-1998
		AU 731442 B	29-03-2001
		AU 3569097 A	30-12-1998
		BR 9714732 A	25-07-2000
		EP 1042587 A	11-10-2000
		GB 2322147 A,B	19-08-1998
		NO 996092 A	09-02-2000
		US 6047774 A	11-04-2000
US 5787987 A	04-08-1998	AU 709101 B	19-08-1999
		AU 6447096 A	13-03-1997
		CA 2184943 A	07-03-1997
		GB 2304764 A,B	26-03-1997
		NO 963711 A	07-03-1997
GB 2330159 A	14-04-1999	CA 2218278 A	10-04-1999
		US 6089320 A	18-07-2000
		NO 983243 A	12-04-1999